IMPACT OF CHANNELIZATION AND ASSOCIATED LAND USE CHANGES ON WILDLIFE HABITAT

By

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USE CHANGES ON WILDLIFE HABITAT

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INTRODUCTION

Riparian habitat is recognized as being vital to many wildlife species for reproduction, protective cover, and/or food (Russel 1966, Holder 1969, National Academy of Sciences 1970, and United States Department of Agriculture-Forest Service 1977). Higher population densities of wildlife species can be supported in riparian habitat than in any other forest type in North America of equal size (Carothers et al. 1974).

In the prairie ecogeographic provinces of the southcentral United States most forest growth occurs in riparian areas (Bailey 1978). Numerous corridors of bottomland forest extend along rivers and streams from the eastern deciduous forests into these prairie provinces. Unfortunately, there is a dearth of relative and detailed historic data on these riparian habitats (USDA-FS 1977).

Since the early 1940's, various government agencies, primarily the Corps of Engineers (COE) and the Soil Conservation Service (SCS), and private groups have undertaken the development, "improvement", and/or modification of at least 321,800 km of waterways in the United States (Council on Environmental Quality 1973:9). These changes have resulted in the drainage of about 53 million ha of wetlands (CEQ 1973:9), and in the clearing of extensive areas of streambank vegetation, thereby having an adverse impact on wildlife species dependent on riparian habitat (Committee on Public Works 1971).

A total of $359,946,970 has been spent on COE and SCS-assisted channel programs, and an additional expenditure of $166,300,000 is proposed for pending projects (CEQ 1973:10-11).

Research on the impact of stream channelization has been concentrated in the eastern and southeastern United States (Fig. 1). Studies have been conducted in the Eastern Deciduous Forest Ecogeographic Province (after Bailey 1976) by Barstow (1971), Prellwitz (1976), and Rice (1976), in the Southeastern Mixed Forest (Bayless and Smith 1964, Ferguson et al. 1975, and Arner et al. 1976), and the Laurentian Mixed Forest (Dodge et al. 1976). Lund (1976) conducted a channelization study in the Columbia Forest Province. Information on the impact of stream alteration on wildlife habitat in the Tall-grass Prairie Ecogeographic Province and on fish habitat in streams of the Prairie Parkland Province is provided by Bonnema (1972) and Bulkley et al. (1976), respectively.

No information has been found in the available literature on the effect of stream alteration on riparian vegetation and wildlife of the prairie ecogeographic provinces of the southcentral United States. Regional information on the impact of stream alteration projects is needed to aid the U.S. Fish and Wildlife Service and other resource agencies in meeting their statuatory obligations under the Fish and Wildlife Coordination Act to evaluate the environmental effects of stream alteration projects (Committee on Government Operations 1973).

Oklahoma, centrally located in the southcentral region, and recipient of major funding for water development and soil conservation programs, has experienced widespread stream alteration due to channelization (Barclay ca 1978a). Oklahoma has 28 major streams with

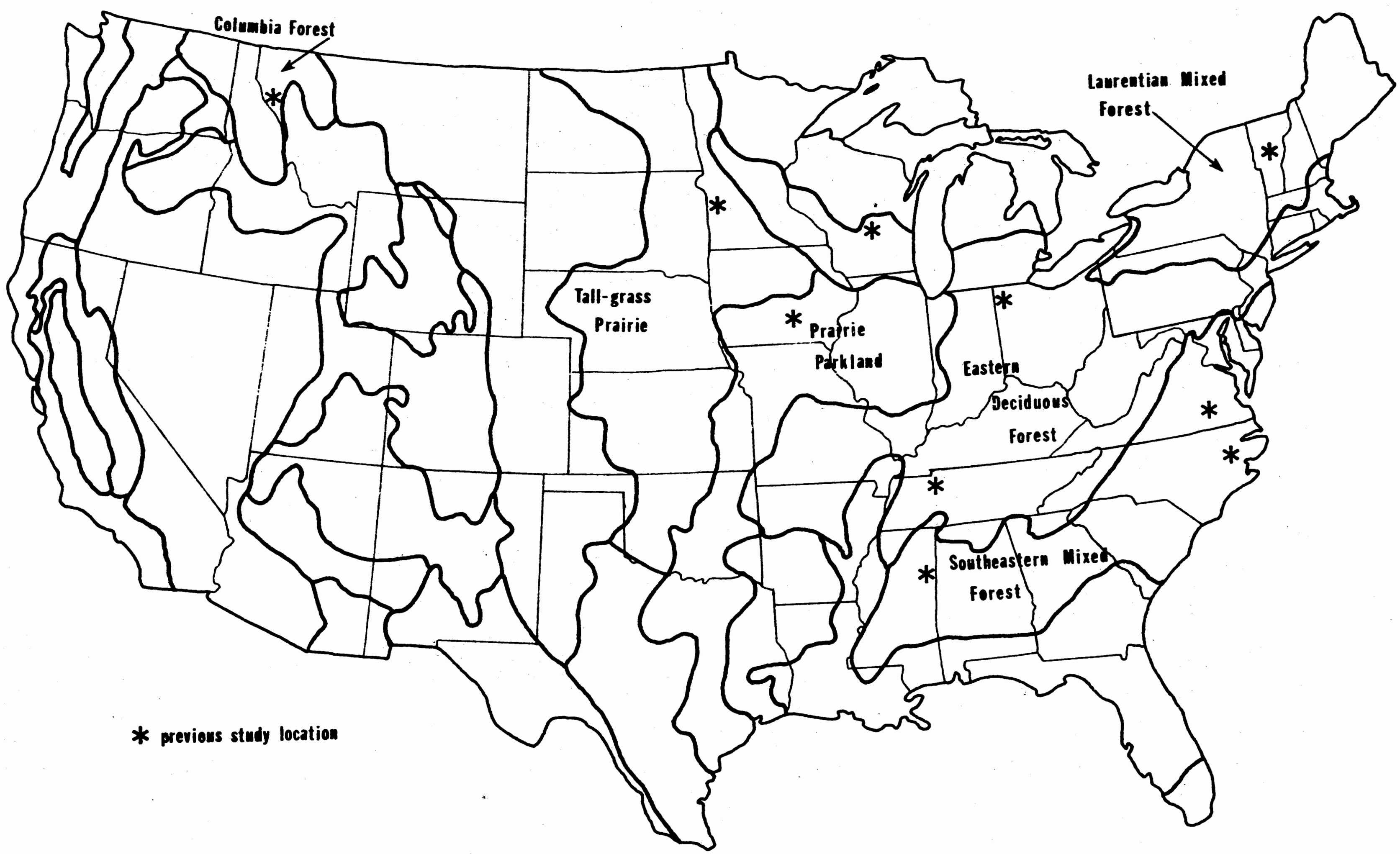

Fig. 1. Location of previous stream channelization projects in the United States by ecogeographic provinces (map after Bailey 1976).

a combined channel length of over 7,800 km, 60% of which lie within the Oak + Bluestem Parkland ecoregion. Several hundred smaller streams, including those selected for this study, flow on an intermittent basis but provide aquatic and riparian habitats for wildlife. More than 900 km of 60 known streams have been channelized, and an additional 1,700 km are planned by various state and federal entities (Barclay ca 1978a).

This research was conducted as part of a comprehensive study to determine the impact of stream alteration on riparian vegetation and associated wildlife populations in the southern grasslands of the United States (Barclay ca 1978b). Funds for the project were provided by the U.S. Fish and Wildlife Service through contract 14-16-0008-2039.

The purpose of this study was to provide quantitative information and a historical perspective on habitat changes associated with stream channelization on selected streams in the southern grasslands of the United States. Specific objectives were to (1) summarize the chronological sequence of channelization activities and their relationship to riparian wildlife habitat within 2 floodplains in southcentral Oklahoma, (2) determine the changes in area of riparian forest within the floodplains of 2 partially channelized streams in southcentral Oklahoma, and (3) determine and interpret historical changes in vegetative cover types, principal game species, and land use within the watersheds.

DESCRIPTION OF STUDY AREA

The study was conducted within the Rush Creek and Wildhorse Creek watersheds in southcentral Oklahoma (Fig. 2). Portions of Carter, Garvin, Grady, Murray, and Stephens counties are included in the watersheds. The 2 streams are a part of the Washita River Watershed.

Rush Creek rises near the town of Rush Springs, Oklahoma in southeast Grady County, and Wildhorse Creek rises in northwest Stephens County near Marlow, Oklahoma. Both streams flow in an easterly direction.

Rush Creek is approximately 97 km long and has a watershed area of 77,581 ha and a floodplain containing 5,767 ha (SCS 1954a). Wildhorse Creek is about 21 km south of Rush Creek and has a length of 108 km. The watershed contains approximately 173,317 ha (SCS 1977a) and the floodplain covers an area 22,073 ha in size (SCS 1953).

Topography, Geology and Soils

The topography is classed as rolling to gently rolling prairie and savannah (SCS 1954a). The relief is interrupted between the 2 streams near the vicinity of Purdy where an escarpment, known locally as the Table Mountains, rises 45-60 m above the plains (SCS 1954a) (Fig. 3). The surface elevation of the study area ranges from 274 to 426 m above mean sea level (Gray and Galloway 1958). The anticline of the Arbuckle Mountains (Fig. 3) lies in an east-west axis on the southeastern edge

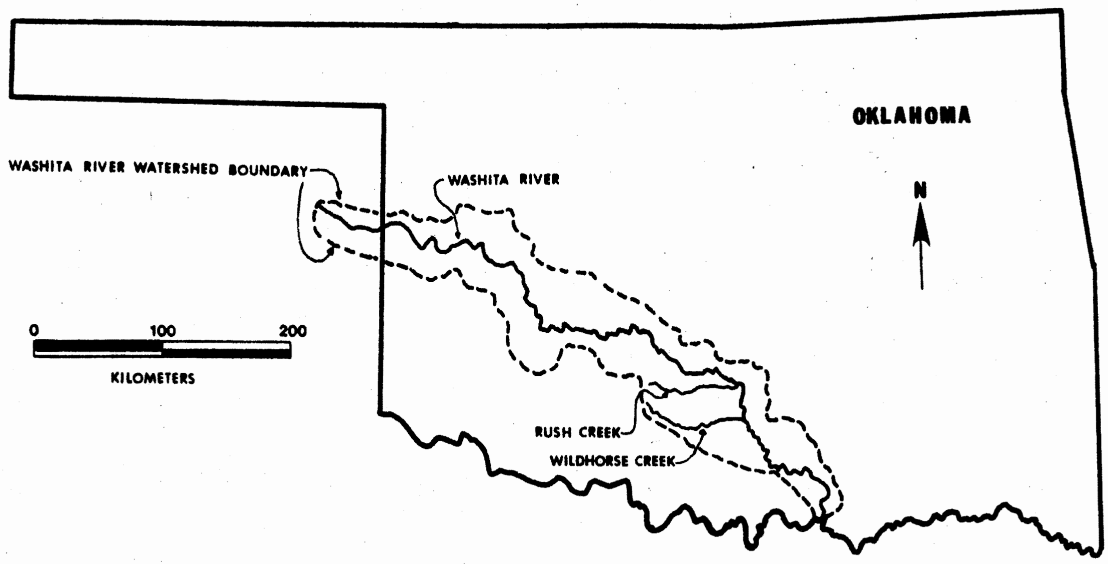

Fig. 2. Relative location of Wildhorse Creek and Rush Creek, selected for study of stream channelization effects in Oklahoma.

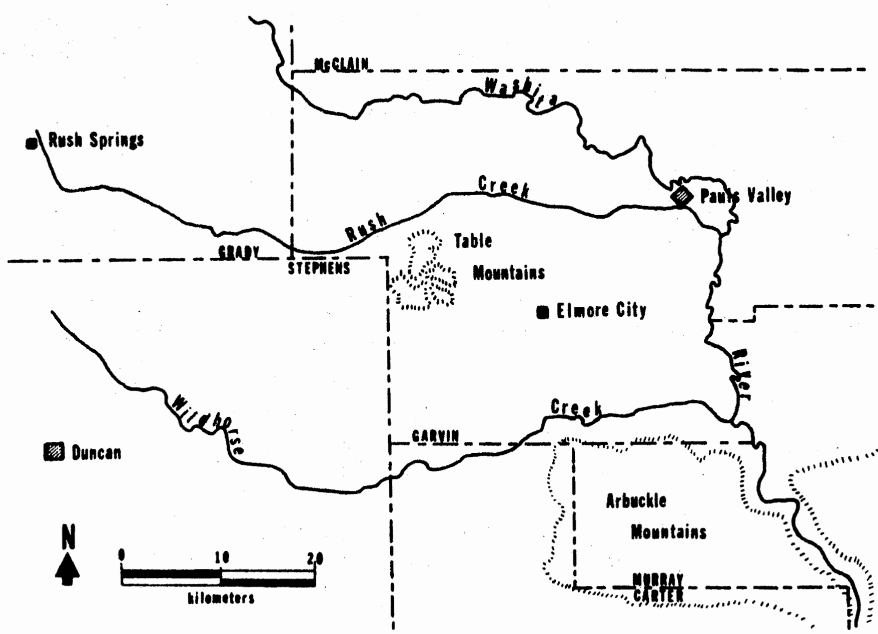

Fig. 3. Relative locations of study streams, Table Mountains, and the Arbuckle Mountains.

of the Wildhorse Watershed. These moutains rise 150 to 180 m above the surrounding terrain (Oklahoma Water Resources Board 1968).

The study area is underlain by predominantly Pennsylvanian and Permian sandstones and shales that are only moderately deformed and have a regional northwestward strike (OWRB 1968). Geologic formations underlying the Rush and Wildhorse watersheds include the Garber Sandstones, Hennessey Shales, and El Reno Groups (SCS 1963).

Darnell-Stephenville and Renfrow-Zaneis-Vernon are the major soil associations found in the study basins. The bottomland soils of the streams are of the Yahola-Port-Reinach association. These soils of the study basins are erosive in nature and have low moisture storage ability (Gray and Galloway 1959).

Climate

The study streams occur in a region characterized by generally mild winters and long, hot summers. The average annual growing season is 212 days (OWRB 1968:28). The mean annual temperature is 16.7 C with mean ranges from about 4.5 C in January to 28.1 C for August. Temperature extremes range from 46 C to -25 C (OWRB 1968:34).

The annual precipitation for the area averages 87.13 cm (OWRB 1968:34). Lake evaporation is approximately 152 cm annually with 70% of the annual loss coming in the May-October period (OWRB 1968:29).

Vegetation

The 2 watersheds studied during the project are within the Oak + Bluestem Parkland Ecoregion (Bailey 1976). According to Duck and Fletcher (ca 1943), Postoak-Blackjack Forest and Tall-grass Prairie are the principal vegetation types of the area. Bands of wooded pasture and prairie transverse the watershed from north to south due to the influence of various geological formations (SCS 1963).

Pecans (Carya illinoensis), cottonwood (Populus deltoides), black walnut (Juglans nigra), and elm (Ulmus sp.) are the major tree species of the riparian forest areas (SCS 1964a). Much of the original riparian forest has been cleared and is now in cropland and bermuda grass (Cynodon dactylon) pasture.

Stream Characteristics

Rush and Wildhorse creeks have average annual flows of approximately 95 million kl and 138 million kl, respectively (OWRB 1968). This is equivalent to an average annual flow of 122,437 kl per 100 ha of watershed for Rush Creek and 79,680 kl per 100 ha of watershed for Wildhorse Creek.

The main alluvial valleys of the study streams vary in width from 61 to 1,824 m (SCS 1954a). The average widths of the floodplains of the 2 streams are approximately 1.3 km.

Chemical analyses of water samples indicate brine contamination in the middle and lower reaches of both streams (OWRB 1968). Sulfate contamination occurs in the upper reaches of both streams where drainage is from gypsiferous rocks (OWRB 1968). Rush Creek has an annual average sediment yield of 9,712 kl per 259 ha of drainage area (SCS 1963). Rush Creek constitutes approximately 4% of the total Washita River drainage area and contributes an estimated 12% of the total annual sediment yield (SCS 1954a). No information could be found in the available literature on the annual sediment yield of Wildhorse

Creek.

The gradient of the 2 streams is approximately 5 m per km near their confluence with the Washita River. Approximately 8 km upstream from their confluence with the Washita River the gradient of both streams increases to 10 m per km (OWRB 1968).

Flooding

As of 1964, the 2 project streams had experienced minor flooding 2-3 times per year and more severe flooding annually (SCS 1963, SCS 1964b). During a 20-year evaluation period from 1923 to 1942, 31 floods that inundated more than 50% of the floodplain and 44 smaller floods occurred on Rush Creek (SCS 1963). Wildhorse Creek had 25 major and 45 minor floods during the same period (SCS 1964b). Major floods also occurred in 1902, 1908, 1943 (Walker 1953), 1950, and 1957 (SCS 1963).

All of the 51 upstream floodwater retarding structures on Rush Creek have been constructed since the 1957 flood; only 5 of the 97 upstream impoundments on Wildhorse Creek had been constructed by 1957 (SCS 1977b).

No major floods occurred on the study streams from 1958 to 1976 (SCS 1977c). Evidence of bank overflow, following a period of heavy rainfall, was observed at most study sites on both streams by project personnel in July 1977.

METHODS AND MATERIALS

Materials and Equipment

Contact prints (scale = 1:20,000) of aerial photographs for 1937, 1949, 1963, and 1969 were obtained from the Aerial Photography Field Office of the Agricultural Stabilization and Conservation Service (ASCS) in Salt Lake City, Utah. These photographs were used to provide information on changes in the extent of riparian forest within the floodplains of the 2 study streams.

United States Geological Survey (USGS) 7½-minute topographic survey maps (scale = 1:24,000) and orthophotoquads (scale = 1:24,000) were used as base maps. The orthophotoquads were used for the extreme western portion of the 2 study streams because 7½-minute topographic maps for that portion of Oklahoma have not been published.

Original land survey plat maps (ca 1871) were obtained from the Eastern States Land Office of the Bureau of Land Management (BLM) and used to provide data on the extent of the original riparian forest and the original stream course and channel length. Measurements of other general land use features sketched on the maps, particularly wetlands, were used in assessing the original wildlife habitat values of the floodplains.

A Bausch and Lomb Zoom Transfer Scope (ZTS) was used to transfer information onto the base maps. With the ZTS, aerial photographs were optically superimposed onto the base maps and the area of riparian forest outlined for later quantification. A pencil of a different color was used for each photograph series to allow all 4 series to be put on a single base map. The ZTS was also used to superimpose the SCS watershed maps onto the orthophotoquads so that floodplain boundaries could be outlined. The accuracy of the plat maps was verified by superimposing them on the topographic maps and matching known features such as section lines and unchannelized sections of stream.

Area of floodplains, riparian forest, and wetlands and length of streams were obtained by use of a Numonics Model 1224 Digitizer from the plat maps and base maps. Digitization of large areas such as floodplains and stream lengths, and areas that were extremely irregular in shape, was repeated 3 times and a mean computed. Other areas were measured only once.

Methods

Thirteen Oklahoma grassland streams with various extents of channelization were considered as potential study areas. The streams were evaluated by aerial and ground reconnaissance. A stream selection matrix was subsequently developed by senior project personnel to evaluate the usefulness and compatibility of each study area to the present study.

The selection matrix was used to rank each area on the basis of values assigned to each of 19 stream characteristics, grouped according to 5 broad parameters: (1) physical, (2) hydrological, (3) informational, (4) proximal, and (5) access. The values were summed, and the total ratings indicated that Rush and Wildhorse creeks were appropriate for use in the investigation.

The floodplain boundaries of Rush and Wildhorse creeks were marked on the topographic maps using contour lines as guides. USGS Flood Prone Area maps, and watershed maps of Rush (SCS 1954_b_) and Wildhorse (SCS 1952) creeks, which showed the approximate floodplain boundaries, were used as references to determine which contour lines to follow. This method was discussed with Oklahoma SCS hydraulic engineer R.C. Riley, and determined to be an accurate and acceptable method for this project. Ten of the 17 plat maps had floodplain boundaries sketched on them by the original surveyors. Floodplain boundaries from the base maps were superimposed and outlined, with the aid of the ZTS, on the 7 maps the surveyors did not delineate floodplain boundaries.

A search of Oklahoma Historical Society records and of the literature available in university and community libraries was made to provide an historical perspective on conditions existing prior to channelization. Garvin County Clerk records were also searched and these provided information on old channelization activities and channel specifications.

Interviews to provide background information were conducted with landowners, SCS personnel, and other persons knowledgeable about the study area. A list of the persons interviewed is provided in Appendix A.

RESULTS

Agricultural and Industrial Development

The Chickasaw Indians settled in the area of the Rush and Wildhorse watersheds in 1838 (Bellows 1932). Their primary occupation was ranching, and they grazed their cattle on the native grasses. Farming activities and land clearing began as early as 1856, with corn being the most valuable crop (Bellows 1932). Around 1900 the cultivation of land became more intense and ranching diminished in importance (Bellows 1932 and Walker 1953). Ignorance of modern farming practices by the early settlers led to widespread land abuse. As the fertility of the shallow upland soils decreased and erosion increased, the fertile bottomlands were cleared and crops planted (SCS 1976). The general shift from the farming of row crops (such as corn and cotton) on the upland prairie areas to the farming of sown crops (mainly alfalfa and wheat) in the floodplains began in the early 1930's (Walker 1953).

The channelization of Rush and Wildhorse creeks in the 1920's and 1930's appears to have greatly facilitated the clearing, drainage, and subsequent farming of the bottomland areas. As the upland areas were removed from farm production they were either allowed to return to native grass species or were converted to tame grass pastures (primarily bermuda grass). The first bermuda grass pastures in Garvin County were planted in 1934 (pers. comm. R.C. Longmire, former chairman, Garvin County Conservation District) and are now quite extensive in the watersheds. Since the 1940's, ranching has again become important although very little native grass pasture remains in either watershed.

The petroleum industry has also been important to the development of this region in more recent times. Oil was discovered northeast of Pauls Valley in April 1942 (Walker 1953). Contained within the Rush and Wildhorse watersheds are portions of 3 giant oil fields (ultimate recovery more than 100 billion barrels) (Oklahoma Geological Survey 1972). The agricultural income of approximately 75% of the landowners in the watersheds has been supplemented by oil royalties and leases (SCS 1963).

Drilling, storage and pumping operations, refining, and other activities associated with the petroleum industry have resulted in land clearing and road construction in some areas, particularly along the western portions of Rush and Wildhorse creeks. These oil field activities would appear to be possible sources of water, soil, and air pollution in the study areas.

Wildlife

Prior to settlement, wildlife was abundant throughout the area. Many species are mentioned in early records (Nice 1931, Blair 1939, and Duck and Fletcher ca 1943) and in interviews with long-time residents of the area (see Appendix A). Buffalo (*Bison bison*), pronghorn antelope (*Antilocapra americana*), and greater prairie chickens (*Tympanuchus cupido*) occurred in large numbers on the plains (SCS 1976). The bottomland forest supported large populations of turkey (*Meleagris gallopavo*), white-tailed deer (*Odocoileus virginianus*) (SCS 1976), swamp rabbits (*Sylvilagus aquaticus*), mink (*Mustela vison*), muskrat

(Ondatra zibethica), oppossums (Didelphis marsupialis), and raccoons (Procyon lotor) (Blair 1939). The riparian areas provided resting and feeding places for migrating ducks, geese, sandhill cranes (Grus canadensis), white (whooping ?) cranes (Grus americana), plovers (Pluvialis spp. and Charadrius spp.), curlews (Numenius spp.) and passenger pigeons (Ectopistes migratorius) (Nice 1931).

The buffalo was exterminated from the area between 1875-80 (Roe 1951) and many other species were exterminated or reduced to low densities by 1900. At the time of statehood in 1907, rabbits, squirrels, oppossums, and raccoons were the only game species left in the area in significant numbers (Bellows 1932).

Restocking programs by the Oklahoma Department of Wildlife Conservation, that started in 1934-36 for turkey and in 1942 for deer (Duck and Fletcher ca 1943) have aided in the return of these species to huntable levels.

The armadillo (Dasypus novemcinctus) has, since 1936, extended its range into Oklahoma (Taber 1939) and is now abundant in the study area (Barclay ca 1978b).

Beaver (Castor canadensis) were originally abundant in riparian areas, but were reduced to low numbers prior to 1940 (Duck and Fletcher ca 1943). Beaver populations have increased dramatically in the last 10-15 years, primarily because of the construction of upstream floodwater retarding structures by the SCS and are again common in the study area (Reynolds 1976).

Population density estimates of bobwhite quail (Colinus virginianus), mourning dove (Zenaidura macroura), Rio Grande Turkey, and white-tailed deer from the Stream Alteration Impact Study (Barclay ca 1978b) were compared with SCS (1976) regional estimates. In all cases, with the exception of turkey, the population densities estimated by the SCS for the region were higher than population densities encountered on the floodplains of Rush and Wildhorse creeks by Barclay (ca 1978b).

Watershed Development

The Flood Control Act of 1944 (Public Law 534) authorized the Secretary of Agriculture to undertake works of improvement for runoff and waterflow retardation and soil erosion prevention in 11 river watersheds in the United States. The Washita Watershed, of which Rush and Wildhorse creeks are a part, was one of the 11 watersheds chosen (SCS 1964b). Original efforts were directed toward the installation of land treatment measures, primarily the revegetation of formerly cultivated lands. By 1947, the planning of floodwater retarding structures, drop inlets, and diversions in small subwatersheds had begun (SCS 1964b). This program has resulted in 51 upstream floodwater retarding structures being built on Rush Creek and 97 upstream impoundments and 11.9 km of channelization on Wildhorse Creek (SCS 1977b). The SCS estimates that 5,797 ha (98%) and 13,355 ha (61%) of Rush and Wildhorse floodplains, respectively, receive some degree of flood protection (SCS 1977a).

Channelization Activities

With the growth of human settlements, ranching on a large scale diminished, and farming intensified (Walker 1953). This intensive cultivation of the land increased pressure to farm the fertile bottomlands and a group of local citizens initiated a movement to channelize Rush and Wildhorse creeks. Petitions were filed with the Board of County Commissioners of Garvin County to form drainage districts for the purpose of channelizing portions of the streams. The petitions state that the channelization would help control the frequent overflows of the streams and was necessary for sanitation and agricultural purposes. Strong opposition developed against both Wildhorse Creek petitions, and this opposition was filed with the Garvin County Commissioners (GCR 1924:423)[1]. In each case the objections were dismissed and then taken to the Oklahoma District Court and Oklahoma Supreme Court. The Supreme Court upheld the commissioners and the drainage petitions. The chronological history of these petitions and channelization activities, plus costs, are summarized in Table 1.

Many smaller segments of the 2 streams and their tributaries have been modified by private landowners. Most of these efforts consisted of cutting a ditch across oxbows to straighten the streams prior to 1937 (e.g. Segments WVI and WVIII, Fig. 4). These smaller areas of channelization were identified from aerial photographs.

The area of most recent channelization was completed on Wildhorse Creek between 1968-71 under technical direction of the SCS (Segment WIV, Fig. 4). Information on this segment of channelization was obtained from Horace M. Haws, Jr., Head of Engineering Design Section of Oklahoma SCS.

Approximately 18 additional kilometers of channelization have been proposed for Wildhorse Creek (SCS 1964) and would extend the channel "improvement" upstream from stream segment WIV (Fig. 4). Also, an

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[1] (GCR 1924:423) indicates that these records are filed by year and page number in the Garvin County Courthouse, Ordinances Binder No. 1, County Clerk's office, Pauls Valley.

Table 1. History and cost of drainage district channelization activities on Rush and Wildhorse creeks.

Drainage district[a]	Petition initiated	Petition approved	Contract let	Work completed	Cost ($)
Rush Creek					
RCDD No. 1 (segment RII,map)	8 July 1919	13 Aug 1919	11 Feb 1921	1921	133,908
RCDD No. 2 (segment RIV,map)	6 Nov 1922	6 Nov 1922	17 Mar 1923	1923	67,493
Wildhorse Creek					
WCDD No. 1 (segment WIII,map)	2 Mar 1923	8 May 1923	23 Feb 1931[b]	1931	29,492
WCDD No. 2 (segment WII,map)	3 Mar 1923	8 May 1923	27 Aug 1932[b]	1933	60,888
SCS Project (segment WIV,map)	late 1950's	1964	1968	1971	528,687

[a]See map, Fig. .

[b]Start of channel work was delayed because protests were filed with the Garvin County Commissioners and decisions to continue with construction were appealed to the District Court and later to the Oklahoma Supreme Court.

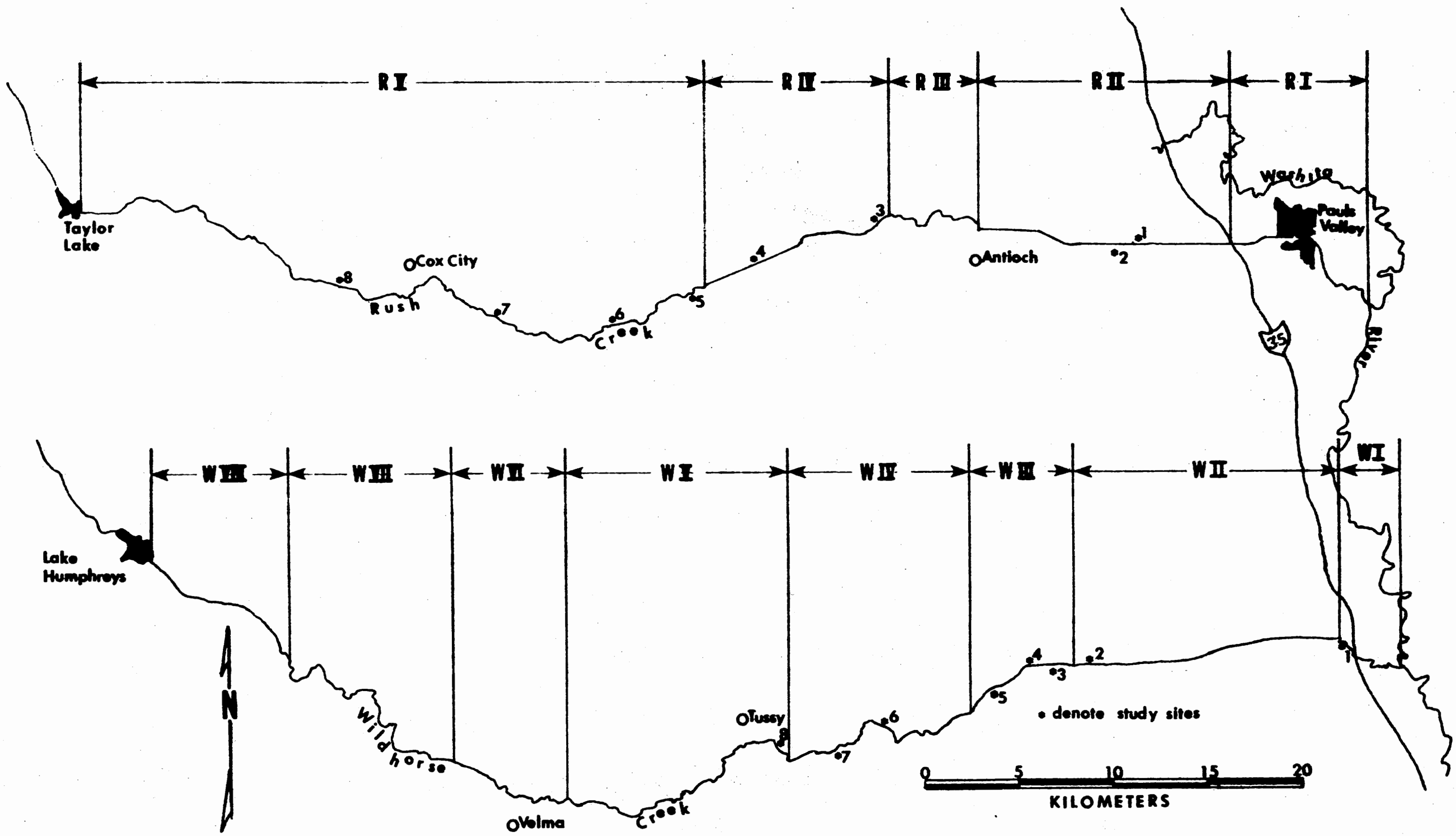

Fig. 4. Map showing stream segments of Rush and Wildhorse creeks plus approximate locations of study sites. Segment channel characteristics are summarized in Table 3.

additional 5 km of channel work was proposed and discussed by SCS personnel during a public meeting in August 1976. If completed, this project would extend the 1933 channel project (Segment WII, Fig. 4) downstream to the confluence of Wildhorse Creek and the Washita River. The completion of these 2 projects, in addition to those already built, would result in a continuous length of channelized stream for approximately 65 km on Wildhorse Creek.

The channelization activities that have occurred on the 2 study streams represent a wide variation in channelization methods. These methods included: (1) construction of new straight-line channels parallel to, but away from, the old channel, principally along the lower reaches of both streams (Fig. 4); (2) construction of a new channel across the meanders but in association with the original channel, principally in the mid-reaches; (3) construction of cut-off channels across 1 or more meanders, shortening the channel and creating a more direct flow, primarily along the upper reaches; (4) enlarging the original channel and eliminating some meanders, as evident in the recent (1968-71) work on Wildhorse Creek.

Physical Characteristics of Streams

A net reduction of 11.8% (10.3 km) and 20.6% (23.3 km) in the original (1871) channel length has occurred on Rush Creek and Wildhorse Creek, respectively, as a consequence of channelization (Table 2). Thus a total combined loss of 33.6 km (16.7%) of stream ecosystem has occurred within the 2 watersheds. In addition, approximately 77.5 km (46%) of the total 167.2 km of existing channels have been channelized.

Channelized segments of stream show a 31.4% (35.5 km) reduction in

Table 2. Changes in stream length by channelized and unchannelized segments between 1871-1969 for Wildhorse and Rush creeks.

Stream segment		Stream length (km)			
Ident. no.[a]	Year channelized	1871 Plat maps	1969-76 Topo.maps	km change	% Change
WI[b]	UC[c]	2.0	2.9	+.9	+31.0
WII, WIII	1933,1931	36.8	20.9	-15.9	-43.2
WIV	1968-71	15.2	11.9	-3.3	-21.7
WV	UC	20.2	20.4	+.2	+1.0
WVI	Pre-1937	11.9	9.0	-2.9	-24.4
WVII	UC	14.2	14.6	+.4	+2.7
WVIII	1937-49	13.0	10.3	-2.7	-20.8
	Wildhorse Total	113.3	90.0	-23.3	-20.6
RII	1922	20.9	14.5	-6.4	-30.6
RIII	UC	8.4	7.3	-.9	-13.1
RIV	1923	15.2	10.9	-4.3	-28.3
RV	UC	43.0	44.5	+1.5	+3.4
	Rush Total	87.5	77.2	-10.3	-11.8
Combined Streams					
Channelized segments		113.0	77.5	-35.5	-31.4
Unchannelized segments		87.8	89.7	+1.9	+2.1
	Total	200.8	167.2	-33.6	-16.7

[a]See Fig. for geographic location of stream segments.

[b]Includes only the portion of stream from WII to I-35.

[c]UC = Unchannelized segment.

length from the comparable original portions, while unchannelized segments show a 2.1% (1.9 km) increase. The largest percentage increase (31%) in length occurred in segment WI, downstream from the channelized segments.

No published information could be found on the original unaltered dimensions of the stream channels. However, engineers' specifications of the work contract by the drainage districts on Rush and Wildhorse creeks were found in obscure Garvin County Clerk records. These specifications, and those of the recent channelization provided by Horace M. Haws, Jr., Head of Engineering Design Section of Oklahoma SCS, were compared with current channel dimensions. The current channel dimensions (width and depth) at each Stream Alteration Impact Study (SAIS) study site (Fig. 4) were measured by project personnel in July 1977.

The relative changes in cross-section of some representative channelized SAIS study sites are illustrated in Fig. 5. The diagram for site W5 in Fig. 4 also compares 1977 measurements of an original meander, cut off when the stream was channelized in 1931, with the 1977 measurements of the present channel. Comparisons of engineers' specifications with current (1977) stream dimensions indicated an estimated 500-800% increase in channel capacity since 1921-33.

Wetland Areas

A total of 54 wetland areas covering 725 ha, as shown on the 1871 plat maps, was digitized. In most instances where forestland did not cover the entire eastern two-thirds of the floodplain, the remaining area (6.2% of floodplain) was in wetlands (Table 3). The floodplain

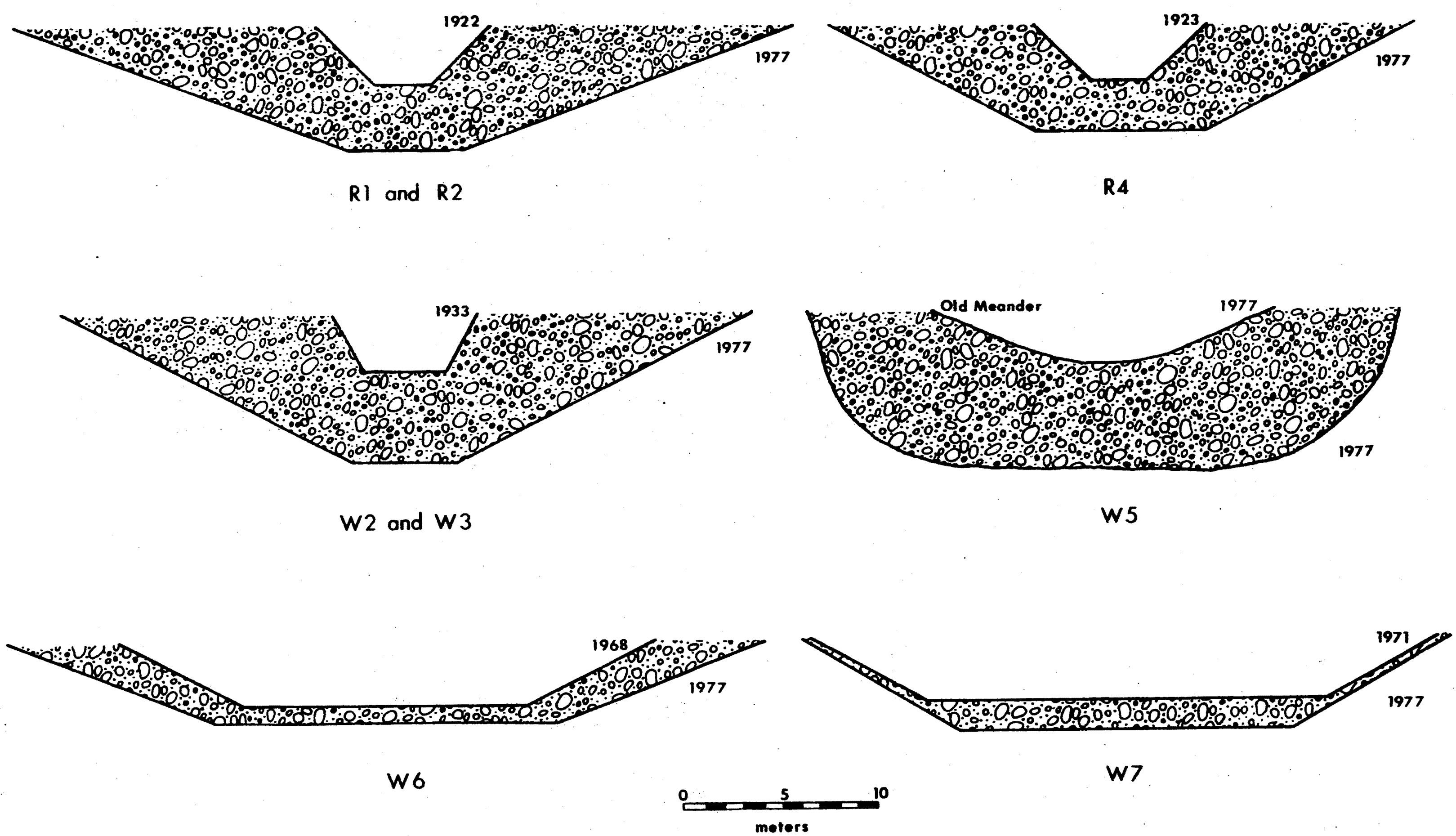

Fig. 5. Diagrammatic channel cross-sections for original (W5 meander), old channelization (R1 and R2, R4, W2 and W3), and recent channelization (W6 and W7) at representative study sites on Rush and Wildhorse creeks, based on original design specifications and 1977 measurements.

Table 3. Number and extent of wetland areas shown on 1871 land survey maps for Wildhorse Creek and Rush Creek floodplains.

	Wildhorse	Rush	Combined
No. of wetlands	40	14	54
Total wetlands area (ha)	562.7	163.8	726.5
Ave. wetland size (ha)	14.1	11.7	13.5
Range: Max. (ha)	147.6	69.9	
Min. (ha)	.6	.6	
Floodplain area* (ha)	6,844.9	4,793.5	11,638.4
% of floodplain area in wetlands	8.2	3.4	6.2
River km**	86.1	57.5	

*Only the eastern portion of floodplains that contained wetlands is included.

**No wetlands were found upstream from this point.

vegetation changed to more open prairie toward the western end of the 2 study streams where soils, geological formations, and periodic runoff were not as conducive to wetland development.

All of the wetlands on Rush Creek were downstream from a point approximately 3 km east of Cox City. The wetlands on Wildhorse Creek began approximately 3 km west of Velma. The Wildhorse Creek floodplain contained more wetlands (40), the largest wetland (147.6 ha), and a larger average wetland size (14.1 ha) than did Rush Creek. No permanent natural wetlands are known to exist within the floodplains at the present time.

Changes in Riparian Forest

Chronological changes in the extent of riparian forest were quantified (Table 4). The study areas extended from Taylor Lake (Rush Creek) and Lake Humphreys (Wildhorse Creek) downstream to where the floodplains are influenced by the Washita River floodplain near Interstate Highway 35. The streams were divided into segments based on date and/or method of channelization (Fig. 4).

Rush and Wildhorse creeks experienced a 93% and 84% reduction in bottomland forest, respectively, from a combined total of 12,102 ha in 1871 to 1,544 ha in 1969.

The floodplain area in riparian forest in 1871, 1937, 1963 and 1969 are illustrated in Fig. 6 (Rush) and Fig. 7 (Wildhorse). The size of each segment in these figures was determined by its length and floodplain area relative to the entire stream. The information for 1949 is not shown because an average of less than 1% change occurred on all stream segments combined between 1937-49. Major reductions in

Table 4. Total floodplain area and changes in area (ha) of bottomland forest for all segments of Wildhorse (W) and Rush (R) creeks from pre-settlement (1871) through 1969 as determined from maps and aerial photos.

Stream segment				Riparian forest area (ha) by major time intervals					Forest % decrease
No.	Type of alteration[a]	Floodplain area (ha) 1871 maps	Floodplain area (ha) 1969 maps	1871	1937	1949	1963	1969	(1871-1969)
WI[b]	UC	266.1	303.9	163.8	98.2	108.2	117.1	99.3	39.4
WII,WIII	REL	2,930.6	3,053.4	2,421.7	635.0	747.2	473.7	447.7	81.5
WIV	ENL	1,124.1	1,133.0	872.2	295.4	319.5	274.3	161.9	81.4
WV	UC	1,631.1	1,635.1	1,449.8	312.1	408.1	341.0	375.1	74.1
WVI	CUT	894.9	1,087.8	762.1	138.3	82.7	70.1	36.7	95.2
WVII	UC	1,008.8	901.4	819.8	237.2	187.6	86.7	61.5	92.5
WVIII	CUT	929.8	940.3	839.2	96.7	65.6	17.4	10.8	98.7
		8,785.4	9,054.9						
	Subtotal (Unchannelized)			2,433.4	647.5	703.9	544.8	535.9	78.0
	Subtotal (Old Channelized)			4,023.0	870.0	895.5	561.2	495.2	87.7
	Subtotal (Recent Channelized)			872.2	295.4	319.5	274.3	161.9	81.4
	Total (Combined)			7,328.6	1,812.9	1,918.9	1,380.3	1,193.0	83.7

Table 4. Continued.

No.	Type of alteration[a]	Stream segment: Floodplain area (ha) 1871 maps	1969 maps	Riparian forest area (ha) by major time intervals: 1871	1937	1949	1963	1969	Forest % decrease (1871-1969)
RII	REL	1,781.9	1,694.2	1,695.2	126.8	95.6	19.6	28.5	98.3
RIII	UC	508.9	490.0	442.9	104.2	61.5	48.6	20.4	95.4
RIV	REL	1,379.2	1,398.1	1,080.1	110.1	122.7	182.4	115.3	89.3
RV	UC	3,473.3	3,241.3	1,554.7	201.3	157.5	157.2	186.4	88.0
		7,143.3	6,823.6						
Subtotal (Unchannelized)				1,997.6	305.5	219.0	205.8	206.8	89.6
Subtotal (Old Channelized)				2,775.3	236.9	218.3	202.0	143.8	94.8
Total (Combined)				4,772.9	542.4	437.3	407.8	350.6	92.7
TOTAL (Both Streams)		15,928.7	15,878.5	12,101.5	2,355.3	2,356.2	1,788.1	1,543.6	87.2

[a]UC = Unchannelized; REL = Channel relocated; ENL = Existing channel enlarged; CUT = Existing channel meanders intersected by new channel.

[b]Includes area from W2 to I-35 only.

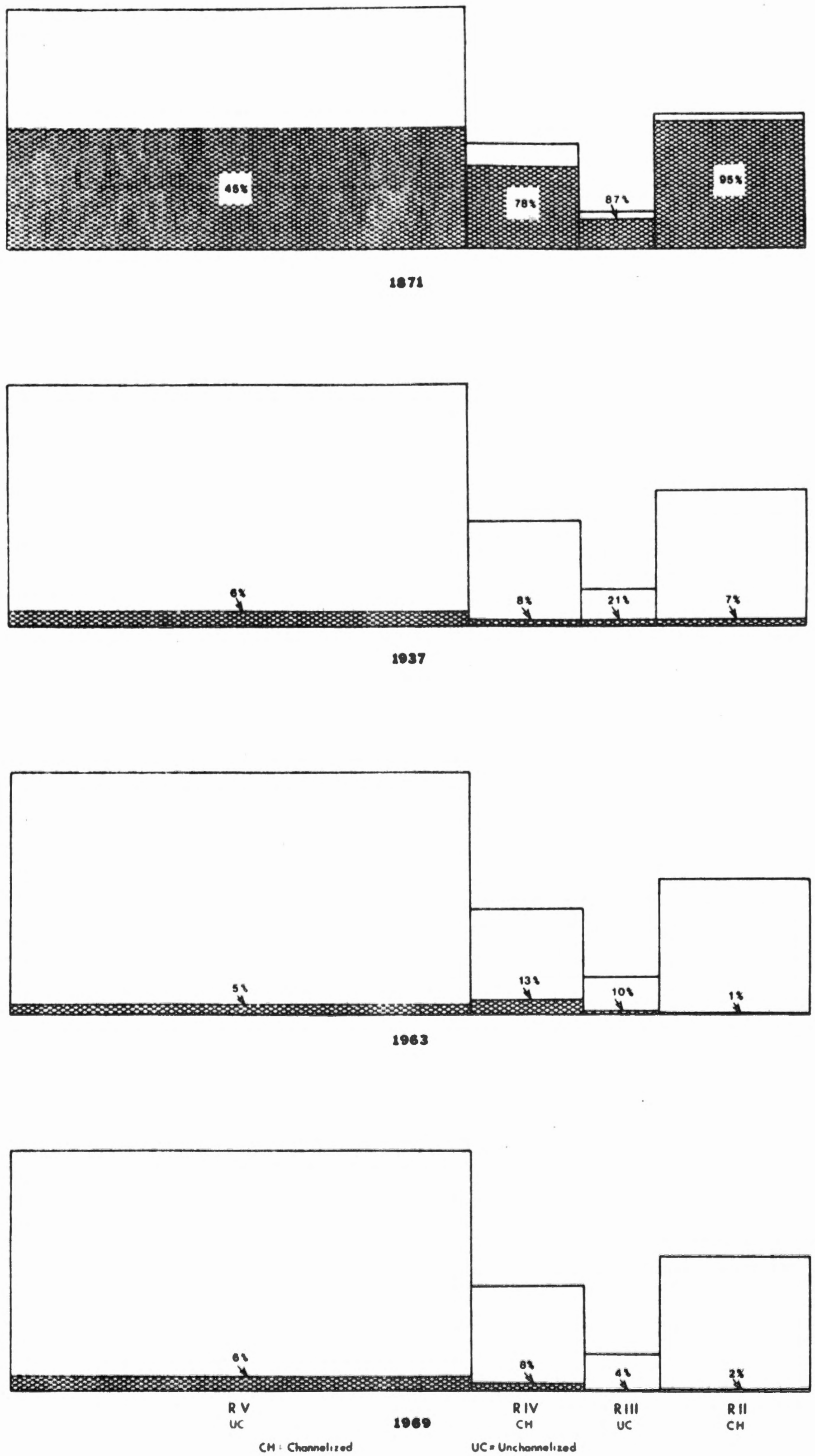

Fig. 6. Relative length and floodplain area of Rush Creek stream segments and percent of floodplain in riparian forest for 1871, 1937, 1963, and 1969.

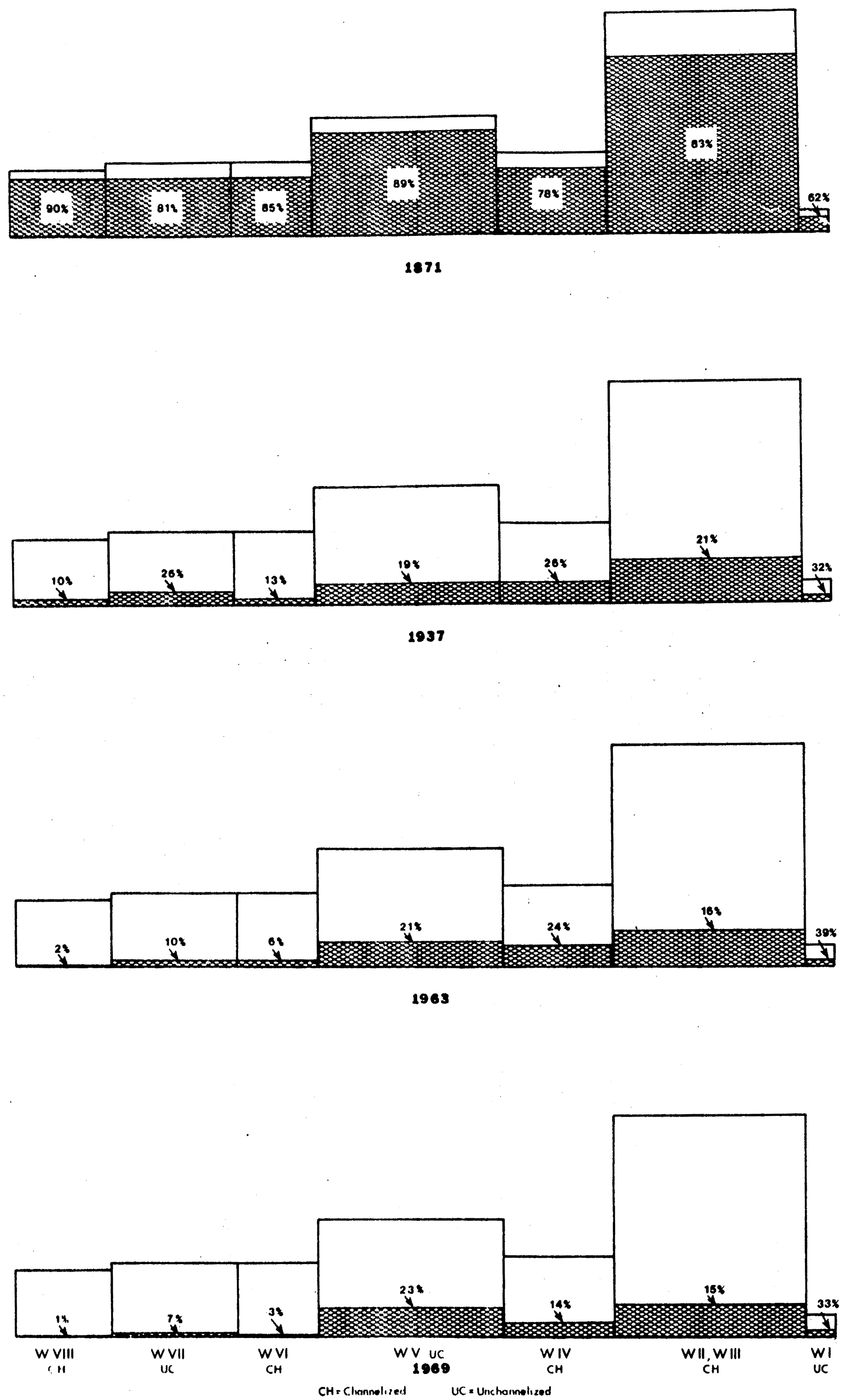

Fig. 7. Relative length of floodplain area of Wildhorse Creek stream segments and percent of floodplain in riparian forest in 1871, 1937, 1963, and 1969.

riparian forest area occurred on all stream segments between 1871 and 1937 but no information could be located to determine whether these changes occurred prior to or after channelization. A substantial decrease in the remaining forestland occurred in segment WVIII during the 1949-63 period. A large portion of the riparian forest lost between 1963-69 was in segment WIV. An estimated 80% of the land removed from riparian forest has been converted to cropland and tame grass pasture.

DISCUSSION

Agricultural Development

Agricultural development has been taking place within the floodplains and watersheds of the 2 study streams during the last 122 years. The desire of landowners to control the frequent overflows of the 2 streams, to allow more efficient use of the floodplains for agricultural purposes, led to the formation of early drainage districts and the subsequent channelization of the streams. The construction of upstream floodwater retarding structures and additional channelization by the SCS and private groups has further facilitated and encouraged the clearing, drainage, and subsequent farming of the bottomlands of Rush and Wildhorse creeks (SCS 1964). The increased flood protection provided by these control measures permits maximum agricultural use of the floodplain area (SCS 1964). The land use changes associated with agricultural development have resulted in the removal of all but a few areas of natural riparian wildlife habitat of biological significance.

Wildlife

Most game species were greatly reduced in numbers or extinct before channelization activities began in 1921. The almost complete destruction of native riparian vegetation has, however, greatly reduced the ability of the area to support the number and densities of wildlife species found along the streams originally. Even though legal protection is now afforded to most animal species, and restocking efforts have been conducted for some, the habitat is no longer available to allow the extant wildlife species to recover from their early exploitation by man.

The clearing of forested areas has apparently permitted the armadillo to extend its range into Oklahoma (Taber 1939). According to Reynolds (1976) the construction of upstream impoundments has allowed the beaver to reestablish itself throughout much of its original range in Oklahoma, including the 2 study watersheds. The majority of beaver in the 2 study watersheds apparently occur on upstream impoundments and not on the streams.

A comparison of the population densities estimated by the SCS for bobwhite quail, mourning dove, and white-tailed deer, and those population densities encountered by Barclay (ca 1978b), seems to indicate that the floodplains of the 2 study streams provide lower quality habitat for these species than does the region in general. However, differences in methods of estimating population densities between the 2 studies may also account for the difference in estimates.

Sufficient information was unavailable to fully accomplish Objective 3. The lack of information on the relative abundance of principal game species in the time period prior to and shortly after channelization made it difficult to determine any changes in these populations as a result of channelization. The lack of information from several time periods for principal game species made it impossible to determine trends in relative densities of these populations. Comparisons of the riparian vegetation and associated wildlife populations on unchannelized and channelized portions of Rush and Wildhorse creeks is provided by Barclay (ca 1978b).

Watershed Development

Upstream floodwater retarding structures provide flood protection to portions of the streams and have allowed agricultural development and the associated land use changes to take place even on the unchannelized segments of stream. The presence of these impoundments may help to explain why the loss of riparian forest has been so complete throughout the watersheds.

No major floods have occurred on the Rush and Wildhorse floodplains since 1957. All but 5 of the 148 upstream impoundments in the 2 watersheds have been installed since that time. This seems to indicate that upstream impoundments play a more significant role in flood control than does channelization since major floods occurred on both streams even after extensive sections of early (1921-33) channelization were constructed. However, these impoundments have resulted in the inundation of approximately 4,838 ha of potential wildlife habitat in the Rush Creek and Wildhorse Creek watersheds. Research should be conducted to determine the relative effectiveness and cost of channelization, impoundments, and other flood control measures in controlling major floods and the relative impact of these control measures on wildlife habitat.

Physical Characteristics of Streams

The reduction in original (1871) channel lengths and loss of associated aquatic habitat has been due primarily to the abandonment and subsequent destruction of the original stream channels. The channelization of approximately 46% of the existing (1969) channels has resulted in a decrease in value of the channels to aquatic and/or riparian flora and fauna. Although an estimated 65.6 km of "new" channel were dredged, creating aquatic habitat where none had existed, but at the expense of the abandoned channels, the quality of the new habitat for most plants and animals is considerably less than that which it replaced (Barclay ca 1978b).

Comparisons between the 1871 plat maps and the aerial photographs indicate that stream segment WI (Fig. 4) has formed additional meanders and enlarged old ones. The increased velocity and force gained by the water as it moves down the channelized segments prior to entering an unchannelized section appears to have accelerated scouring and deposition in the latter areas. Results of this process are evident in the diagram of channel cross-sections (Fig 5).

Additional apparent effects of the reduction in stream length and/or the channelization process itself include impact on tributaries, increased erosion and probable lowering of the water table. Nearly all of the tributaries of both streams have been deliberately altered or inadvertantly cut downward by erosion outward from the mainstem, especially in the lower reaches. The presence of some flowing water in a few tributaries plus the main channels during the summer 1976 drought may have been due to constant drainage of associated aquifers plus leakage from upstream impoundment. Because the low water flows are about 6-9 m below the floodplain in channelized reaches, some aquifer drainage probably is occurring (pers. comm. Dr. Douglas Kent, OSU geologist).

Constant cutting, erosion, and slumping of the streambanks has greatly increased the width and depth of the streams (Fig. 5). Bank cutting on Rush Creek was negligible until after it was straightened in 1921-23, according to long-time residents (SCS 1963). The increased sediment yield of Rush Creek due to erosion, at least partially the result of channelization, is also thought to be responsible for channel widening on the Washita River below its confluence with Rush Creek (SCS 1963).

Wetlands

The reduction in frequency of flooding plus a lowered water table brought about by channelization have resulted in the drainage of wetlands and/or created conditions which are not suitable for the formation or maintenance of wetland areas. The large number of upstream impoundments also appears to have helped to reduce flooding, thereby contributing to the downstream loss of wetlands (SCS 1976).

Changes in Riparian Forest

Major land use changes have occurred in both floodplains since 1871. The period from 1871 to 1937 accounts for the highest percentage of change on all stream segments (Table 4). It was during this time that the major channelization projects on both streams were completed. Unchannelized stream segments had a lower percentage loss (76%) than did the channelized stream segments (84%) for the 1871-1937 time period.

One factor that may account for the lack of change in forestland area for the 1937-49 time period is that this time span includes World War II, and it is most likely that there was a lack of manpower, funds, and/or equipment to undertake new land clearing efforts.

The largest percentage loss (73.5%) of remaining forestland that occurred from 1949-63 was on the stream segment WVIII immediately below Lake Humphreys, which was constructed during this time period (1957). It is probable that the partial flood protection provided by this lake encouraged landowners immediately downstream to clear land for agricultural purposes.

The segment of Wildhorse Creek channelized by the SCS between 1968-71 (WIV) showed the largest percentage loss in riparian forest for the 1963-69 period. This loss was probably due to the clearing of rights-of-way for the new channel.

Most stream segments had an increase in riparian forest during 1 or more time periods. The increase in forestland is probably due to forest regrowth in these areas. The forest regrowth areas apparently do not provide habitat of as high a quality as the virgin forest areas (Barclay ca 1978b). The measurement of these regrowth areas resulted in an overestimate of the amount of high quality riparian forest habitat available to wildlife species.

Plans prepared by the SCS to channelize the upper and lower reaches (segments WVII and WI, respectively), if implemented, would probably contribute to the destruction of much of the remaining riparian forest.

SUMMARY

Agricultural development and associated land use changes have occurred with and been facilitated by channelization activities.

Channelization and subsequent land use changes along the 2 study streams have resulted in or facilitated an extensive loss and degradation of aquatic habitat; accelerated erosion; complete destruction of wetlands; and nearly complete elimination (87%) of the riparian forest.

Current plans for additional channelization of Wildhorse Creek, plus persistant land clearing activities, should result in the complete elimination of any biologically significant riparian habitats along the streams within a few years.

Most (81%) of the original 12,102 ha of riparian forest and associated 726.5 ha of wetlands were lost prior to 1937. However, the remaining unchannelized segments are bordered by an average of 5-10% proportionally more area of bottomland forest than are the channelized segments. This supports the conclusion that channelization has been a major factor in elimination of riparian forests along the 2 streams.

Channelization has resulted in a 16.7% reduction in length of the original 1871 streams, and an estimated 500-800% increase in channel capacity due to erosion. The loss in channel length per channelized segment ranged from 21-43%.

Upstream floodwater retarding structures appear to be more

effective in controlling flooding along the 2 streams than is channelization. Even with major channelization projects in place major floods were common. The installation of impoundments since 1957 appears to have reduced major flooding. Upstream impoundments have resulted in the inundation of approximately 4,838 ha of potential wildlife habitat in the Rush Creek and Wildhorse Creek watersheds.

The population densities of most game species appear to be much lower than historical populations. Wildlife population densities in the project watersheds also appear to be lower than the average SCS density estimates for nearby areas.

RECOMMENDATIONS

A regional survey should be conducted to determine changes in extent and characteristics of present riparian habitats.

The mitigation provisions of the Fish and Wildlife Coordination Act should be enforced. This would allow the aquisition of riparian habitats via easements or purchase.

More riparian wildlife habitat should be acquired for public hunting and other non-consumptive uses through the implementation of 3 to 1 Federal-State-cost/sharing fish and wildlife enhancement under the Federal Water Project Recreation Act. This would help prevent the loss of these valuable habitats to changes in land use practices.

Research should be conducted to determine the relative effectiveness and cost of channelization, impoundments, and other flood control measures in controlling floods and the relative impact of these control measures on wildlife habitat.

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APPENDIX

LIST OF PERSONS INTERVIEWED

Dale Bell. SCS District Conservationist, Pauls Valley Field Office. 20 July 1976.

Paul Copeland. Retired SCS District Conservationist, Pauls Valley Field Office. 30 June 1976.

Dale Davis. SCS Soil Conservationist, SCS State Office, Stillwater. 19 July 1976.

Glenna Graham. Long-time resident and daughter of R.C. Kennedy (contractor of early channel work for drainage district). 16 August 1976.

Tom Hayes. Retired SCS District Engineer, Pauls Valley Field Office. 1 July 1976.

Parmin Hensen. Amateur naturalist and long-time resident and landowner near Rush Creek. 9 July 1976.

Tom Peachy Howell, III. Long-time resident and landowner near Wildhorse Creek. 23 July 1976.

George E. Johnson. Long-time resident and landowner near Wildhorse Creek. May 1976.

Fred Kennedy. Long-time resident and landowner near Rush Creek. Brother of R.C. Kennedy (contractor for early channelization projects on Rush and Wildhorse creeks). 9 July 1976.

Otho LaMar. SCS District Conservationist, Duncan Field Office. 12 July 1976.

Erwin D. Leaverton. Head of SCS Watershed and River Basin Planning Staff, Chickasha. 12 July 1976.

C.T. Loftin. Long-time resident and landowner near Rush Creek. 5 August 1976.

R.C. (Dick) Longmire. Long-time resident and landowner and former chairman of Garvin County Conservation District. 10 July 1976.

Sam D. Lowe. Retired SCS District Engineer, Pauls Valley Field Office. 10 July 1976.

Willie Newbury. Long-time resident and landowner near Wildhorse Creek. May 1976.

P.J. Newby. Long-time resident and landowner near Rush Creek. 22 July 1976.

Judge Haskell Paul. Great-grandson of Smith Paul, founder of Pauls Valley. Long-time resident and landowner near Rush Creek. 10 July 1976 and 24 July 1976.

Bobby Perkins. Long-time resident and landowner near Wildhorse Creek. June 1976.

Herbert Prince. Long-time resident and landowner near Wildhorse Creek. June 1976.

Clifford E. Rhoads. SCS District Conservationist, Ardmore Field Office. 21 July 1976.

Charlie Ritchison. Long-time resident and landowner near Rush Creek. 4 August 1976.

Daryl D. Rowley. SCS District Conservationist, Rush Springs Field Office. 22 July 1976.

Donald R. Vandersypen. SCS Assistant State Conservationist (Water Resources), Stillwater. 27 October 1978.

Jim Wingo. Long-time resident and landowner near Wildhorse Creek. June 1976.

VITA 2

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Master of Science

Thesis: IMPACT OF CHANNELIZATION AND ASSOCIATED LAND USE CHANGES ON WILDLIFE HABITAT

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